Assessment of Exposure to Volatile Organic Compounds in New and Sick Houses Indoor Environments

Kyong Whan Moon, Sang Hoon Byeon, Dal Woong Choi, Young Whan Kim, Jang Hee Lee*, Eun Il Lee**

Department of Environmental Health, College of Health Sciences, Korea University
Environmental Health Research Center, College of Health Sciences, Korea University
**Department of Preventive Medicine, College of Medicine, Korea University*

Abstract

32 Volatile organic compounds(VOCs) were measured by thermal desorption/gas chromatography/ mass spectrometry in normal houses, new and sick houses.

The sum concentrations of aromatic hydrocarbons in living room of new and sick houses showed 606 $\mu g/m^3$ and 645 $\mu g/m^3$, respectively. These figures were about 40 times higher than the values 14 $\mu g/m^3$ in normal houses. Among the chlorinated hydrocarbons trichloroethylene in the new and sick houses were at least 50-100 times higher than the mean concentrations in normal houses. But no significant differences could be shown for the concentration of VOCs in indoor air between new houses and sick houses ($p<0.05$).

Introduction

Volatile organic compounds (VOCs) are organic chemical compounds that have high enough vapour pressures under normal conditions to significantly vaporize and enter the atmosphere. A wide range of carbon-based molecules, such as aldehydes, ketones, and hydrocarbons are VOCs. The presence of VOCs in indoor air has been associated with adverse health effects such as sensory irritation, odor and the more complex set of symptoms called the Sick Building Syndrome (SBS). More recently, a possible link between the increase in the prevalence of allergies throughout the industrialized areas and exposure to elevated concentrations of VOCs, acting as adjuvant factors, has been suggested.[Andersson 1997].

In the indoor air, VOCs are emitted mainly from household products such as paints, varnishes, glues, construction materials, furnishings and other behaviour-linked activities. Therefore, dozens of VOCs have been identified in indoor air and the range of measured concentrations of different VOCs is extremely wide.

However, indoor air includes hundreds of compounds and there are growing interest in identifying all possible VOCs, since some of them may cause symptoms resembling sick building syndrome[Ritso 1995].

In this study we have identified 55 VOCs in 15 houses, which were categorized as normal houses, new houses and sick houses, by thermal desorption/gas chromatography/mass spectrophotometry(TD/GC/MS).

Experimental

The houses in this study were single family houses or apartments in a block of flats. The houses were categorized with the following criteria : normal houses were older than five years, no repairs were done during the last one year, and new houses were constructed in a year, and the people living in both houses had not complained of any symptoms. In this study the houses, were recently constructed in a year and in which people complained about the ordor or they had symptoms, which resembles the sick building syndrome such as headache and nausea, were divided as sick houses. The subjects of investigation were 5 houses, respectively.

Air sampling for VOCs analysis were conducted in a living room and bed room at a place well away from known or suspect sources by SKC low flow pump. Sampling tubes were used stainless steel tubes(Gerstel, Germany), filled with 250 mg Tenax TA(60-80 mesh), which were conditioned, prior to use, by heating at 300°C for 8 hours, flowing helium at 50 ml/min. The VOCs collected on the Tenax TA trap were analyzed by coupling a thermal desorption system(TDS A2, Gerstel, Germany) to a GC/mass spectrophotometry (HP 6890N/HP 5973, USA). Standard solution EPA TO-1 Toxic Organic Mix(Supelco, USA), containing benzene, toluene and other chemicals at 2,000 μg/ml each in methanol and n-hydrocarbon Mix(Supelco, USA), were used for preparing calibration solutions.

The analysis comprised concentrations of 32 VOCs belonging to the groups of aromatics and volatile halogenated hydrocarbons.

Result and discussion

Table 1 summarizes the results obtained for the compounds quantified in the each sampling points. As can be seen aromatic compounds showed the high levels and many kinds of halogenated compounds were detected. Among aromatic hydrocarbons toluene, ethylbenzene and xylene were most frequently found and highly detected almost all the houses samples. And benzene known for showing carcinogenic effect also observed high levels.

The sum concentrations of aromatic hydrocarbons in living room of new and sick houses showed 606 μg/m^3 and 645 μg/m^3, respectively. These figures were about 40 times higher than the values 14 μg/m^3 in normal houses and about 20 times higher compare to the outdoor air. But no significant differences could be shown for the concentration of VOCs in indoor air between new houses and sick houses ($p<0.05$).

Among the chlorinated hydrocarbons the concentrations trichloroethylene and 1,4-dichlorobenzene were the most prevalent VOCs, followed by trimethybenzenes and chlorotoluenes. Especially trichloroethylene in the new and sick houses were 50-101 μg/m^3 and at least 50-100 times higher than the mean concentrations in normal houses.

The measured sum of VOCs in this study were higher than earlier results, which had been reported as about 200-400 μg/m^3. [Park 2004, Rehwagen 2003]

Table. 1 Mean concentrations.(㎍/m') of VOCs in indoor and outdoor air of normal, new houses and sick houses

Compounds	bed roon(n=15)			living room(n=15)			Outdoor(n=15)		
	normal	new	Sick	normal	new	sick	normal	new	sick
Aromatic hydrocarbons									
Benzene	1.144	48.473	52.160	1.378	63.847	46.562	1.124	3.025	2.141
Toluene	7.716	97.793	196.727	7.365	128.323	146.276	5.044	21.30	12.757
Ethylbenzene	0.680	79.269	71.760	1.239	100.886	94.430	1.065	4.100	4.025
p-Xylene	0.728	43.986	16.432	0.713	106.171	70.189	1.854	2.828	2.121
m-Xylene	1.420	108 616	76.630	1.390	116.86	78.607	8.522	4.832	8.358
styrene	0.213	20.354	47.759	0.169	63.630	50.238	0.026	4.081	14.280
sec-Butylbenzene	1.629	4.459	4.715	0.074	5 619	6.933	0.018	2.483	3.430
tert-Butylbenzene	0.022	10.103	10.116	0.006	9.272	7.827	0.023	0.000	1.906
n-Butylbenzene	2.848	0.000	3.439	0.000	1.441	3.759	1.794	2 211	3.026
n-Propylbenzene	0.052	5.720	8.393	1.946	10.015	11.343	2.443	2.881	4.186
Sum of aromatics	16.452	418.77	488.13	14.28	606.06	516.16	21.913	47.741	56.23
Halogenated hydrocarbons									
Bromobenzene	0.000	2.081	0.000	0.000	2.905	2.011	0.000	0.000	1.262
Chlorobenzene	0.019	1.547	2.301	0.017	3.150	1.991	0.017	0.378	1.218
1,3-Dichlorobenzene	0.000	0.000	3.596	0 014	0.000	4.019	0.000	2.317	1.738
1,4-Dichlorobenzene	1.595	4.768	20.484	0.180	8.736	22.295	0.027	4.717	4.187
1,2,3-Trichlorobenzene	0.007	0.491	0.000	0.375	0.525	2.353	4.144	0.539	0.404
1,2,4-Trichlorobenzene	0.020	0.011	0.275	0.643	0.515	0.789	2.181	0.000	0.000
4-Chlorotoluene	0.019	5.054	6.147	1.809	6.234	12.577	0.015	2.713	3.794
2-Chlorotoluene	0.045	5.354	6.863	2.483	7.534	7.444	2.091	5.370	3.903
1,2,4-Trimethylbenzene	2.210	9.462	41.561	5.698	21.893	9.362	0.416	5.564	5.861
1,3,5-Trimethylbenzene	0.132	4.457	4.263	0.137	11.104	0.206	1.988	2.813	2.110
Trichloroethylene	0.632	82.242	55.192	1.087	50.588	101.225	0.644	1.437	1.928
Tetrachloroethylene	0.023	2.857	4.649	2.678	3.813	4.319	2.051	5.310	4.342
1,2-Dichloroethylene	0.000	0 000	0.836	0.000	0.698	1.513	0.000	0.000	0.996
Dichromethnane	0.031	0.665	0.743	0.392	2.528	1.589	0.003	0.950	0.799
cis-1,3-Dichloropropane	0.000	0.000	0.000	0.464	0.000	0.000	2.835	0.000	0.000
1,3-Dichloropropane	0.000	0.000	0.239	0.000	0.441	0.000	0.000	0.000	0 000
1,2,3-Trichloropropane	0.037	0.000	3.278	1.845	1.803	2.744	0.659	0.000	0.016
1,1,2,2-Tetrachloroethane	0.017	2.181	3.463	1.841	5.779	7.601	0.021	5.640	3.870
1,1,1-Trichloroethane	0.079	3 007	1.826	0.040	0.845	0.374	2.165	0.075	0.239
Chloroform	0.182	0.211	36.381	0.396	0.176	0.000	0.479	0.271	0.355
Carbon Tetrachloride	0.131	2.829	3.977	1.221	0.063	0.360	0.134	0.042	1.022
1,1,1,2-Tetrachloroethane	0.000	0.000	1.362	3.196	0.000	0.000	0.000	0.000	0.000
Sum of halogens	5.187	127.21	197.71	24.51	129.33	182.77	21.951	38.13	38.04

Conclusion

It was shown that the concentrations of VOCs exceeded the normal level more high in the new and sick houses than in the normal houses. But no significant differences could be shown between new and sick houses The most common VOCs in indoor air were toluene, ethylbenzene, xylene, benzene, trichloroethylene, 1,4-dichlorobenzene, trimethybenzenes and chlorotoluenes.
But it is difficult to generalize the results because the subjects were considered only 5 houses, respectively. Therefore more investigations are needed in the future.

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